Mellanox InfiniBand OFED Driver for VMware vSphere 5.X

User Manual

Rev 1.8.0

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Revision History

Table 1 - Revision History

Revision	Date	Change Description
1.8.0	June 2012	Document restructuring and minor content updates
1.4.1-2.0.000	May 2011	Initial release

About this Manual

This document provides instructions for installing and using drivers for Mellanox Technologies ConnectX®-2 and ConnectX®-3 based network adapter cards in a VMware ESXi Server environment.

Intended Audience

This manual is intended for system administrators responsible for the installation, configuration, management and maintenance of the software and hardware of InfiniBand adapter cards. It is also intended for application developers.

Typographical Conventions

Table 2 - Typographical Conventions

Description	Convention	Example
File names	`file.extension`	
Directory names	`directory`	
Commands and their parameters	**`command param1`**	
Optional items	`[ ]`	
Mutually exclusive parameters	`{ p1 | p2 | p3 }`	
Optional mutually exclusive parameters	`[ p1 | p2 | p3 ]`	
Prompt of a *user* command under bash shell	`hostname$`	
Prompt of a *root* command under bash shell	`hostname#`	
Prompt of a *user* command under tcsh shell	`tcsh$`	
Environment variables	VARIABLE	
Code example	`if (a==b){};`	
Comment at the beginning of a code line	!, #	
Characters to be typed by users as-is	**bold font**	
Keywords	**bold font**	
Variables for which users supply specific values	*Italic font*	
Emphasized words	*Italic font*	*These are emphasized words*
Pop-up menu sequences	menu1 --> menu2 -->... --> item	
Note	**Note:**	

Table 2 - Typographical Conventions

Description	Convention	Example
Warning	**Warning!**	

Common Abbreviations and Acronyms

Table 3 - Abbreviations and Acronyms

Abbreviation / Acronym	Whole Word / Description
B	(Capital) 'B' is used to indicate size in bytes or multiples of bytes (e.g., 1KB = 1024 bytes, and 1MB = 1048576 bytes)
b	(Small) 'b' is used to indicate size in bits or multiples of bits (e.g., 1Kb = 1024 bits)
FW	Firmware
HCA	Host Channel Adapter
HW	Hardware
IB	InfiniBand
LSB	Least significant *byte*
lsb	Least significant *bit*
MSB	Most significant *byte*
msb	Most significant bit
NIC	Network Interface Card
SW	Software
IPoIB	IP over InfiniBand
PFC	Priority Flow Control
PR	Path Record
SL	Service Level
SRP	SCSI RDMA Protocol
ULP	Upper Level Protocol
VL	Virtual Lanes

Glossary

The following is a list of concepts and terms related to InfiniBand in general and to Subnet Managers in particular. It is included here for ease of reference, but the main reference remains the *InfiniBand Architecture Specification*.

Table 4 - Glossary

Channel Adapter (CA), Host Channel Adapter (HCA)	An IB device that terminates an IB link and executes transport functions. This may be an HCA (Host CA) or a TCA (Target CA).
HCA Card	A network adapter card based on an InfiniBand channel adapter device.
IB Devices	Integrated circuit implementing InfiniBand compliant communication.
IB Cluster/Fabric/ Subnet	A set of IB devices connected by IB cables.
In-Band	A term assigned to administration activities traversing the IB connectivity only.
LID	An address assigned to a port (data sink or source point) by the Subnet Manager, unique within the subnet, used for directing packets within the subnet.
Local Device/Node/ System	The IB Host Channel Adapter (HCA) Card installed on the machine running IBDIAG tools.
Local Port	The IB port of the HCA through which IBDIAG tools connect to the IB fabric.
Master Subnet Manager	The Subnet Manager that is authoritative, that has the reference configuration information for the subnet. See Subnet Manager.
Multicast Forwarding Tables	A table that exists in every switch providing the list of ports to forward received multicast packet. The table is organized by MLID.
Network Interface Card (NIC)	A network adapter card that plugs into the PCI Express slot and provides one or more ports to an Ethernet network.
Standby Subnet Manager	A Subnet Manager that is currently quiescent, and not in the role of a Master Subnet Manager, by agency of the master SM. See Subnet Manager.
Subnet Administrator (SA)	An application (normally part of the Subnet Manager) that implements the interface for querying and manipulating subnet management data.
Subnet Manager (SM)	One of several entities involved in the configuration and control of the subnet.
Unicast Linear Forwarding Tables (LFT)	A table that exists in every switch providing the port through which packets should be sent to each LID.

Related Documentation

Table 5 - Reference Documents

Document Name	Description
MFT User's Manual	Mellanox Firmware Tools User's Manual. See under `docs/` folder of installed package.
MFT Release Notes	Release Notes for the Mellanox Firmware Tools. See under `docs/` folder of installed package.

Support and Updates Webpage

Please visit http://www.mellanox.com > Products > Software > Adapter IB/VPI SW/VMware Drivers for downloads, FAQ, troubleshooting, future updates to this manual, etc.

1 Mellanox InfiniBand OFED Driver for VMware® vSphere Overview

1.1 Introduction to Mellanox InfiniBand OFED for VMware

Mellanox OFED is a single Virtual Protocol Interconnect (VPI) software stack based on the OpenFabrics (OFED) Linux stack adapted for VMware, and operates across all Mellanox network adapter solutions supporting up to 56Gb/s InfiniBand (IB) and 2.5 or 5.0 GT/s PCI Express 2.0 and 3.0 uplinks to servers.

All Mellanox network adapter cards are compatible with OpenFabrics-based RDMA protocols and software, and are supported with major operating system distributions.

1.2 Introduction to Mellanox InfiniBand Adapters

Mellanox InfiniBand (IB) adapters, which are based on Mellanox ConnectX®, ConnectX®-2 and ConnectX®-3 adapter devices, provide leading server and storage I/O performance with flexibility to support the myriad of communication protocols and network fabrics over a single device, without sacrificing functionality when consolidating I/O. For example, IB-enabled adapters can support:

- Connectivity to 10, 20, 40 and 56Gb/s InfiniBand switches
- A unified application programming interface with access to communication protocols including: Networking (TCP, IP, UDP, sockets), Storage (NFS, CIFS, iSCSI, SRP and Clustered Storage), Clustering (MPI, DAPL, RDS, sockets), and Management (SNMP, SMI-S)
- Communication protocol acceleration engines including: networking, storage, clustering, virtualization and RDMA with enhanced quality of service

1.3 Mellanox OFED Package

1.3.1 Software Components

MLNX_OFED_VMware contains the following software components:

- CPU architectures:
  - x86_64
- ESXi Hypervisor:
  - ESXi5.0 with BUILD ID: 469512
  - ESXi5.0 U1 with BUILD ID: 623860
- Firmware versions:
  - ConnectX®-2: 2.9.1000 and above
  - ConnectX®-3: 2.10.0700 and above

1.4 mlx4 InfiniBand Driver

MLNX-OFED-ESXi package contains:

- MLNX-OFED-ESXi-1.6.8.zip - Hypervisor bundle which contains the following kernel modules:
  - mlx4_core (ConnectX family low-level PCI driver)
  - mlx4_ib (ConnectX family InfiniBand driver)
  - ib_core
  - ib_sa
  - ib_mad
  - ib_umad
  - ib_ipoib

1.4.1 ULPs

IPoIB

The IP over IB (IPoIB) driver is a network interface implementation over InfiniBand. IPoIB encapsulates IP datagrams over an InfiniBand connected or datagram transport service. IPoIB prepends the IP datagrams with an encapsulation header, and sends the outcome over the InfiniBand transport service. The interface supports unicast, multicast and broadcast. For details, see Chapter 4.1, “IP over InfiniBand”.

On VMware ESXi Server, IPoIB supports Unreliable Datagram (UD) mode only, note that Reliable Connected (RC) mode is not supported.

1.5 Supported Hardware Compatibility

For the supported hardware compatibility list (HCL), please refer to:

http://communities.vmware.com/cshwsw.jspa?vendor=mellanox

2 Installing Mellanox InfiniBand OFED Driver for VMware vSphere

This chapter describes how to install and test the Mellanox InfiniBand OFED Driver for VMware vSphere package on a single host machine with Mellanox InfiniBand hardware installed.

The InfiniBand OFED driver installation on VMware ESXi Server 5.0 is done using VMware's VIB bundles.

Please uninstall any previous Mellanox driver packages prior to installing the new version.

➢ ***To install the driver:***

1. Log into the ESXi5.0 server with root permissions.

```
#> esxcli software vib install -d <bundle_file>
```

2. Reboot the machine.
3. Verify the driver was installed successfully.

```
#> esxcli software vib list | grep Mellanox
net-ib-core          1.6.8 OEM.500.0.0.472560       Mellanox PartnerSupported  2012-05-09
net-ib-ipoib         1.6.8 OEM.500.0.0.472560       Mellanox PartnerSupported  2012-05-09
net-ib-mad           1.6.8 OEM.500.0.0.472560       Mellanox PartnerSupported  2012-05-09
net-ib-sa            1.6.8 OEM.500.0.0.472560       Mellanox PartnerSupported  2012-05-09
net-ib-umad          1.6.8 OEM.500.0.0.472560       Mellanox PartnerSupported  2012-05-09
net-mlx4-core        1.6.8 OEM.500.0.0.472560       Mellanox PartnerSupported  2012-05-09
net-mlx4-ib          1.6.8 OEM.500.0.0.472560       Mellanox PartnerSupported  2012-05-09
```

After the installation process, all kernel modules are loaded automatically upon boot.

3 Uninstalling Mellanox InfiniBand OFED Driver

➢ ***To uninstall the driver:***

1. Log into the ESXi5.0 server with root permissions.

```
#> esxcli software vib remove -n net-ib-ipoib
#> esxcli software vib remove -n net-mlx4-ib
#> esxcli software vib remove -n net-ib-umad
#> esxcli software vib remove -n net-ib-sa
#> esxcli software vib remove -n net-ib-mad
#> esxcli software vib remove -n net-ib-core
#> esxcli software vib remove -n net-mlx4-core
```

2. Reboot the server.

4 Driver Features

4.1 IP over InfiniBand

4.1.1 IPoIB Overview

The IP over IB (IPoIB) driver is a network interface implementation over InfiniBand. IPoIB encapsulates Datagram transport service. The IPoIB driver, ib_ipoib, exploits the following Connect®X/ConnectX®-2/ConnectX®-3 capabilities:

- Uses any CX IB ports (one or two)
- Inserts IP/UDP/TCP checksum on outgoing packets
- Calculates checksum on received packets
- Support net device TSO through CX LSO capability to defragment large datagrams to MTU quantas.
- Unreliable Datagram

IPoIB also supports the following software based enhancements:

- Large Receive Offload
- Ethtool support

4.1.2 IPoIB Configuration

1. Install the Mellanox OFED driver for VMware
2. Verify the driver VIBs are installed correctly. Run:

```
# esxcli software vib list | grep -i Mellanox
```

(a.k.a "esxcfg-nics -l")

3. Verify the uplinks state is "up". Run:

```
# esxcli network nic list | grep -i Mellanox
```

(a.k.a "esxcfg-nics -l")

See your VMware distribution documentation for additional information about configuring IP addresses.

5 Configuring the Mellanox InfiniBand OFED Driver for VMware vSphere

5.1 Configuring an Uplink

To configure an Uplink:

1. Add the device as an uplink to an Existing vSwitch using the CLI.
   a. Log into the ESXi server with root permissions.
   b. Add an uplink to a vSwitch.

```
#> esxcli network vSwitch standard uplink add <uplink_name> -v <vswitch_name>
```

2. Verify the uplink is added successfully.

```
#> esxcli network vSwitch standard list <vswitch_name>
```

➢ ***To remove the device locally:***

1. Log into the ESXi server with root permissions.
2. Remove an uplink from a vSwitch.

```
#> esxcli network vSwitch standard uplink remove <uplink_name> -v <vswitch_name>
```

For further information, please refer to:

http://pubs.vmware.com/vsphere-50/topic/com.vmware.vcli.migration.doc_50/cos_upgrade_technote.1.9.html#1024629

5.2 Configuring VMware ESXi Server Settings

VMware ESXi Server settings can be configured using the vSphere Client. Once the InfiniBand OFED driver is installed and configured, the administrator can make use of InfiniBand software available on the VMware ESXi Server machine. The InfiniBand package provides networking and storage over InfiniBand. The following sub-sections describe their configuration.

This section includes instructions for configuring various module parameters.

From ESXi 5.0 use esxcli system module parameters list **`-m <module name>`** for viewing all the available module parameters and default settings.

When using ESXi, use vMA or remote CLI vicfg-module.pl to configure the module parameters in a similar way to what is done in the Service Console (COS) for ESXi.

5.2.1 Subnet Manager

The driver package requires InfiniBand Subnet Manager (SM) to run on the subnet. The driver package does not include an SM.

If your fabric includes a managed switch/gateway, please refer to the vendor's user's guide to activate the built-in SM.

If your fabric does not include a managed switch/gateway, an SM application should be installed on at least one non-ESXi Server machine in the subnet. You can download an InfiniBand SM such as OpenSM from www.openfabrics.org under the Downloads section.

5.2.2 Networking

The InfiniBand package includes a networking module called IPoIB, which causes each InfiniBand port on the VMware ESXi Server machine to be exposed as one or more physical network adapters, also referred to as uplinks or vmnics. To verify that all supported InfiniBand ports on the host are recognized and up, perform the following steps:

1. Connect to the VMware ESXi Server machine using the interface of VMware vSphere Client.
2. Select the "Configuration" tab.
3. Click the "Network Adapters" entry which appears in the "Hardware" list.

   A "Network Adapters" list is displayed, describing per uplink the "Device" it resides on, the port "Speed", the port "Configured" state, and the "vSwitch" name it connects to.

To create and configure virtual network adapters connected to InfiniBand uplinks, follow the instructions in the ESXi Server Configuration Guide document.

All features supported by Ethernet adapter uplinks are also supported by InfiniBand port uplinks (e.g., VMware® VMotionTM, NIC teaming, and High Availability), and their setting is performed transparently.

5.2.3 Virtual Local Area Network (VLAN) Support

To support VLAN for VMware ESXi Server users, one of the elements on the virtual or physical network must tag the Ethernet frames with an 802.1Q tag. There are three different configuration modes to tag and untag the frames as virtual machine frames:

1. Virtual Machine Guest Tagging (VGT Mode)
2. ESXi Server Virtual Switch Tagging (VST Mode)
3. External Switch Tagging (EST Mode)

EST is supported for Ethernet switches and can be used beyond IB/Eth Gateways transparently to VMware ESXi Servers within the InfiniBand subnet.

To configure VLAN for InfiniBand networking, the following entities may need to be configured according to the mode you intend to use:

- Subnet Manager Configuration

  Ethernet VLANs are implemented on InfiniBand using Partition Keys (See RFC 4392 for information). Thus, the InfiniBand network must be configured first. This can be done by configuring the Subnet Manager (SM) on your subnet. Note that this configuration is needed for both VLAN configuration modes, VGT and VST.

  For further information on the InfiniBand Partition Keys configuration for IPoIB, see the Subnet Manager manual installed in your subnet.

  The maximum number of Partition Keys available on Mellanox HCAs is:

  - 128 for ConnectX® IB family
  - Check with IB switch documentation for the number of supported partition keys
- Guest Operating System Configuration

For VGT mode, VLANs need to be configured in the installed guest operating system. This procedure may vary for different operating systems. See your guest operating system manual on VLAN configuration.

In addition, for each new interface created within the virtual machine, at least one packet should be transmitted. For example:

Create a new interface (e.g., <eth1>) with IP address <ip1>.

To guarantee that a packet is transmitted from the new interface, run:

```
arping -I <eth1> <ip1> -c 1
```

- Virtual Switch Configuration

  For VST mode, the virtual switch using an InfiniBand uplink needs to be configured. For further information, see the *ESXi Server 3 Configuration Guide* and *ESXi Server 3 802.1Q VLAN Solutions* documents.

5.2.4 Maximum Transmit Unit (MTU) Configuration

On VMware ESXi Server machines, the MTU is set to 1500 bytes by default. IPoIB supports larger values and allows Jumbo Frames (JF) traffic up to 4052 bytes on VI3 and 4092 bytes on vSphere 5. The maximum value of JF supported by the InfiniBand device is:

- 2044 bytes for the InfiniHost III family
- 4052 / 4092 bytes for ConnectX® IB family (vSphere 5)

Running a datagram IPoIB MTU of 4092 requires that the InfiniBand MTU is set to 4k.

It is the administrator's responsibility to make sure that all the machines in the network support and work with the same MTU value. For operating systems other than VMware ESXi Server, the default value is set to 2044 bytes.

The procedure for changing the MTU may vary, depending on the OS. For example, to change it to 1500 bytes:

- On Linux - if the IPoIB interface is named ib0, run:

  ```
  ifconfig ib0 mtu 1500
  ```

- On Microsoft® Windows - execute the following steps:

  a. Open "Network Connections"

  b. Select the IPoIB adapter and right click on it

  c. Select "Properties"

  d. Press "Configure" and then go to the "Advanced" tab

  e. Select the payload MTU size and change it to 1500

  f. Make sure that the firmware of the HCAs and the switches supports the MTU you wish to set.

  g. Configure your Subnet Manager (SM) to set the MTU value in the configuration file. The SM configuration for MTU value is per Partition Key (PKey).

  For example, to enable 4K MTUs on a default PKey using the OpenSM SM6, log into the Linux machine (running OpenSM) and perform the following commands:

  h. Edit the file:

```
/usr/local/ofed/etc/opensm/partitions.conf
```

and include the line:

```
key0=0x7fff,ipoib,mtu=5 : ALL=full;
```

i. Restart OpenSM:

```
/etc/init.d/opensmd restart
```

To enable 4k mtu support: run **"esxcli system module parameters set -m=mlx4_core -p=mtu_4k=1"**.
Changes will take effect after the reboot.

5.2.5 High Availability

High Availability is supported for both InfiniBand network and storage adapters. A failover port can be located on the same HCA card or on a different HCA card on the same system (for hardware redundancy).

To define a failover policy for InfiniBand networking and/or storage, follow the instructions in the *ESXi Server Configuration Guide* document.